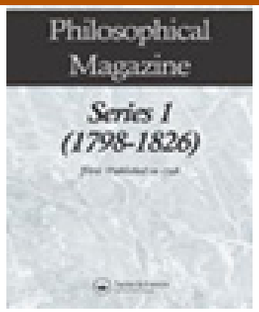

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LXVII. On the specific gravities of the Gases, and the different musical Sounds which they occasion in the same Organ-Pipe

Mr. John Farey Sen.

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requisite to elicit the magnitude of all the equations, which regulate the inequalities in the lunar motions.

If the revisers of the lunar theory had not been more successful in their efforts than Mr. Yeates towards *cultivating more perfectly the lunar astronomy*, the science would have been extremely low in the scale of improvement, compared with its present elevation.

I remain, sir, yours truly,

Norfolk-street, Lynn Regis, Dec. 4, 1820. JAMES UTTING.

P. S. With the *Editor's* permission, I beg leave to express my sentiments of esteem, being principally indebted to the works of *Dr. Hutton* for that information which I have acquired in the sciences, and by my own application only. I sincerely congratulate this gentleman on the receipt of the very respectful letter from the Marquis De Laplace, confirming the truth and originality of the very laborious and intricate Calculations of the mean Density of the Earth, and confirming beyond all doubt *the universal attraction of matter ! ! !* J. U.

LXVII. *On the Specific Gravities of the* GASES, *and the different Musical* SOUNDS *which they occasion in the same* ORGAN-PIPE. *By Mr.* JOHN FAREY *Sen.*

To Mr. Tilloch.

SIR, — I HAVE on two occasions * endeavoured to call the attention of any Experimentalists, who might have the opportunities which I myself do not possess, and who might be so inclined, to the trying experimentally, of the truth of that theory, which assigns *an Interval between the Sounds produced in a given Pipe, by two different Gases, which is measured by the inverse Subduplicate Ratio of the specific Gravities of these Gases.*

At the periods to which I allude, sufficient precision had not been given to the experimental determinations of the *specific Gravities*, of many of the Gases, but which important *data*, have now lately been supplied, by our eminent and indefatigable chemist, Dr. Thomson, of Glasgow; who has taken the utmost care in procuring 26 different Gases, unmixed, and in a state of purity, and in weighing these Gases, and calculating their specific Gravities, in which latter operation, he has availed himself (in all

* P. M. vol. xxxvii. p. 3, and Edin. Ency. vol. x. p. 120.

but

but one of these instances *) either of the known composition, or of the known combinations of the Gases, to correct his experimental results.

Names of Gases.	Specific Gravities. Multiples of Hydrogen	Specific Gravities. Multiples of Atm. Air.	Intervals of Sounds Σ	+f	+m
Hydrogen	1	$\frac{5}{7\,3}$	1177·5000	23	102
Vapour of Carbon	6	$\frac{5}{1\,3}$	386·4291	8	33
CarburettedHydrogen	8	$\frac{5}{9}$	259·5039	5	22
Ammonical Gas	$8\frac{1}{2}$	$\frac{8\,5}{1\,4\,6}$	232·6593	5	20
Vapour of Phosphorus	12	$\frac{5}{6}$	80·5748	1	7
Phosphuretted Hydrogen	13	$\frac{6\,5}{7\,3}$	45·1346	1	4
Azote	14	$\frac{3\,5}{3\,0}$	12·4740	0	1
Carbonic Oxide	14	$\frac{3\,5}{3\,0}$	12·4740	0	1
Olefiant Gas	14	$\frac{3\,5}{3\,6}$	12·4740	0	1
Bihydroguret of Phosphorus	14	$\frac{8\,5}{3\,0}$	12·4740	0	1
ATMOSPHERIC AIR	$14\frac{2}{5}$	$\frac{1}{1}$	0	0	0
Deutoxide of Azote	15	$\frac{2\,5}{2\,4}$	18·0709	0	2
Oxygen	16	$\frac{1\,0}{9}$	46·5000	1	4
Vapour of Sulphur	16	$\frac{1\,0}{9}$	46·5000	1	4
Sulphuretted Hydrogen	17	$\frac{8\,5}{7\,3}$	73·3011	1	6
Muriatic Acid Gas	$18\frac{1}{2}$	$\frac{1\,8\,5}{1\,4\,4}$	110·6276	2	10
Protoxide of Azote	22	$\frac{5\,5}{3\,0}$	187·0510	4	16
Carbonic Acid	22	$\frac{5\,5}{3\,0}$	187·0510	4	16
Cyanogen	26	$\frac{6\,5}{6}$	260·8614	5	23
Sulphuretted Acid	32	$\frac{2\,0}{9}$	352·5039	7	30
Fluoboric Acid	34	$\frac{1\,7\,0}{7\,3}$	379·3407	7	33
Protoxide of Chlorine	$35\frac{1}{5}$	$\frac{2\,9}{9}$	394·5510	8	34
Chlorine	36	$\frac{5}{6}$	404·5000	8	35
Chloracarbonic Acid	50	$\frac{1\,2\,5}{3\,0}$	549·5039	11	47
Hydriodic Acid Gas	63	$\frac{3\,5}{8}$	651·5304	13	56
Vapour of Iodine	125	$\frac{6\,2\,5}{7\,3}$	954·0039	19	82

* Dr. Thomson's experimental result as to *Fluoboric Acid* Gas, was 2·3694: the limits of probable errors in this determination, and the analogies of the Table in the Text, seem to me to point, at 34 times the weight of Hydrogen, or 2·3611, which I have assumed; it will be fortunate, if theoretical deductions from the composition of this Gas, should hereafter confirm and establish this.

In

In Dr. T.'s Table, the specific Gravity of *atmospheric Air* is assumed to be 1·0000, and that of *Hydrogen* is found to be 0·0694; this last, and 21 others of the numbers expressing the specific Gravities, being *repeating* decimals; as an expert Arithmetician would at once perceive, from observing the prime Number 3, to be a multiple, in so many of the Denominators of the Fractions, in the third column of my Table, in the last page; wherein I have omitted these repeating Decimals, and in column 2, set down the Numbers, expressing, how many times the weight of Hydrogen, answers to the weight of each Gas, under equal Bulks and Pressures. The vulgar Fractions in column 3, express the relations which the several specific Gravities, indicated in col. 1, bear to 1 (or $\frac{1}{1}$) which is here set against atmospheric or common air.

The square-roots of the Fractions in col. 3, have furnished the *Ratios*, from whence the corresponding musical Intervals in col. 4, have been calculated, and expressed in the correct Notation which I had the honour of proposing to musical Calculators, through your pages, in the year 1807 *.

For some of your Readers who may not have the Volume at hand, it may be useful here to mention, that the Symbols Σ, f and m, standing at the top of their respective ranges of Figures in col. 4, express three small musical Intervals; their respective magnitudes being such, that $612\Sigma + 12\,f + 53\,m$, exactly make an *Octave*, having the Ratio $\frac{2}{1}$; $358\Sigma + 7\,f + 31\,m$ make a *Fifth* ($\frac{3}{2}$); $197\Sigma + 4\,f + 17\,m$ make a major *Third*; and $11\Sigma + m$ make a major *Comma*, having the Ratio $\frac{80}{81}$, &c. as in the Table referred to: the Interval m being at the same time so exceedingly minute, as scarcely to be appreciable by the Ear, in the most extreme case; as may be judged from the fact, of the Fraction expressing the Ratio of the lengths of two Strings calculated to yield it, having the first five of its figures alike, in the Numerator and in the Denominator, and a difference of only 3 appearing, in the sixth places of these figures; its decimal value with respect to Σ as an unit is ·0078624; The middle Interval f, though more considerable in value, so that a difference of 7 appears in the fifth figures of its Fraction, and so that its decimal value in terms of Σ is ·1496610, is very small, and unimportant in practical utility, except in as far, as the number of fs in any expression in the Table, shows, how many of the vulgar *Half-notes* of Musicians, are contained in the Interval designated: it will for instance, be perceived from inspecting the middle or f range, that phosphuretted Hydrogen is the first Gas which exceeds atmospheric Air in the acuteness of its Sound, by the quantity of half a Note; and in like manner, that Oxygen is the first

* See vol. xxvii. Plate V. p. 140, and vol. xlix. pp. 360 and 362.

Gas

Gas whose sound is a half-note more grave, than the sound of this standard Air.

It so happens, through the peculiar progressions in which the numbers of the three ranges expressing Σ, f and m, increase each way, from 0 against the Standard Air, that for every purpose of comparison, and for almost the nicest purposes of calculation, the two latter ranges may be disregarded, and the numbers (and their decimals) in the Σ range, may be considered as *artificial Commas*, exactly 612 of which make up an Octave. It will be perceived, that only one Gas at the top of the Table, exceeds in acuteness by an Octave, the Standard Sound of common Air, and only two at its bottom, exceed it in graveness by an Octave.

Four years ago, when I first extended Mr. Liston's tuning process, by means of *perfect* Fifths, Thirds and Octaves, only, so as to produce 612 different Notes within the Octave, the object which I had in view, was, so to regulate the extension of my enlarged Tuning Table (which I have described in p. 444 of your 49th volume) in different directions, as to obtain *the most simple Literal Expressions* for the several Notes, near to the borders of the Table (p. 446 Note); that is, that the least number of ♯s or of ♭s, and of ′s, or ‵s, should appear, affixed to the original or simple Literals C, D, E, F, G, A and B: and it was not until some time after your 49th volume was completed, that I was sufficiently struck, with the derangements of the Series formed by the numbers of fs and the numbers of ms, in this my first extended Tuning Table.

Since then, I have, on further considering the subject, constructed such an enlarged Tuning Table, as produces 612 Notes in the Octave, such, that in each of the three Columns, headed Σ, f and m, *an increasing series of numbers appears*, without any exceptions: by which Table, such a close connexion is established, between my Notation of Intervals, and the most perfect (or common) Chord, K, III, V, VIII, and with the only correct mode of Tuning, (invented by Mr. Liston), as cannot ultimately fail, of causing its universal adoption by musical Writers, and by the Teachers, of the principles of the musical Scale: however the present race of Writers and Teachers may continue to act respecting it.

The numbers of f and of m, in the last column of the Table in p. 413, are conformable to my last Tuning Table above mentioned: and which Table, it is my intention to publish at no very distant day. I am

Your obedient servant,

37, Howland-street, Fitzroy-square, Oct. 27, 1820. JOHN FAREY Sen.

LXVIII. *On*